GUAM AGRICULTURAL EXPERIMENT STATION
ISLAND OF GUAM
Under the supervision of the
UNITED STATES DEPARTMENT OF AGRICULTURE

REPORT OF THE GUAM AGRICULTURAL EXPERIMENT STATION

1928

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GUAM AGRICULTURAL EXPERIMENT STATION, ISLAND OF GUAM

[Under the supervision of the Office of Experiment Stations, United States Department of Agriculture]

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REPORT OF THE DIRECTOR

By C. W. Edwards

The work of the station during the fiscal year covered by this report was largely a continuation of that begun in previous years. Because of local conditions and the fact that the station is the only agency on the island carrying on agricultural investigations, the work necessarily includes within its scope a relatively large number of activities. On account of the small personnel and limited facilities, many of these activities can be conducted on a small scale only and they must therefore be extended over a comparatively long period before permitting the drawing of definite conclusions.

In the earlier history of the station the agronomic work was confined largely to a determination of the kinds of crops that can be satisfactorily grown locally. At present it is devoted more to a determination of the varieties of these crops best adapted to Guam conditions, the proper cultural methods to be used for their production, their economic uses, and to means of securing their adoption in practice. The latter work is seriously handicapped by the lack of field agents or an extension force.

The station is giving considerable attention to the production of improved pasture and coarse forage crops. The native varieties of forage, especially the upland pasture grasses, are decidedly inferior to certain of the introduced varieties. With the introduction of new blood as a means of upgrading the livestock of the island, improved feeds must be provided.

Cultural tests with *Paspalum dilatatum*, the leading introduced pasture grass, were continued. Results of one of the tests indicate that on certain upland sword grass (*Miscanthus floridulus*) areas, which are too rocky to permit of ordinary cultivation, Paspalum grass may be grown without any previous preparation or later cultivation of the soil except that of cutting the sword grass at the time the Paspalum is planted and at intervals until the crop is well established. In a fertilizer test concluded during the year the plats receiving barnyard manure and lime in combination gave higher yields of Napier grass and Japanese cane than did the plats on which these materials were used singly. In the case of Guatemala grass the plat receiving lime alone gave the best results. Plats receiving applications of manure alone, as compared with plats receiving lime singly and in combination with manure, gave the second highest yield of Napier grass, Guatemala grass, and Japanese cane. In another test the ground local limestone (cascajo) proved to be a better fertilizer for Napier grass than did the locally burned lime. Adaptability tests with coarse forages were continued. In a planting of Napier grass, Guatemala grass, Merker grass, Japanese cane, and *Pennisetum setosum*, made on a limestone hillside, Napier grass gave the highest and Japanese cane the lowest total yield of green forage.

Guam soils are greatly in need of humus. The heavy lowland clays are poor in texture and much of the upland clay loams are rather low in fertility and moisture-holding capacity. The use of barnyard manure as a means of improving them is impossible because the stabling of animals is not generally practiced. Under present conditions leguminous crops should be grown and plowed under to improve the soils of the island. Legumes can also be used as cover crops and as such are especially desirable where it is necessary to suppress weed growth. For these reasons the station has for some years given much attention to green manure and cover-crop investigations.

Probably because of the possible use of the grain as a human food, the local farmers have shown more interest in the cowpea than in some of the other introduced legumes. It, therefore, would seem best to encourage the growth of varieties giving a satisfactory grain yield while making a fairly good cover crop to improve the soil. Tests are being conducted to determine which varieties best meet these requirements. During the year Conch gave the highest grain yield of seven varieties tested, and it also made a satisfactory cover crop.

Growing the pigeon pea under the plan whereby the crop is topped at intervals and the material is placed between the rows seems to offer a practical means of improving the soil, particularly the texture of the heavy, lowland areas. Work designed to furnish information on this subject was begun in January, 1926. The first test was a failure owing to the death of many of the plants during the rainy season. One topping of a miscellaneous planting yielded 9.6 tons of green forage per acre.

The work with root crops was continued. In a variety planting of sweetpotatoes a Hawaiian seedling variety gave the highest yield, followed by Yap, a native variety, and Nancy Hall, in the order named. The edible canna is gradually filling a particular need in the list of local root crops, especially in districts where taro can not

be grown. A variety of yautia which was introduced by the station years ago is becoming popular with the people of the island.

The work in horticulture included mainly care of the station orchard, disease-control studies, and propagation experiments with citrus, avocados, and mangoes. The native oranges include a tangerine and various grades or subvarieties of a larger orange known as the "cahit." The native orange, especially the cahit, is generally preferred to the imported orange to provide a morning beverage. Until within recent years the cahit orange was abundantly produced on the island, but disease, particularly scaly bark, has destroyed so many of the trees that at present the yield is not sufficient to meet local demands. The tangerine, or naranghita, seems to be immune or highly resistant to this disease. In an effort to remedy the situation the station is growing naranghita seedlings, which are highly resistant to the disease, for distribution to local farmers, and resistant sour-stock seedlings for budding with the cahit and other varieties. To replace many of the lime and lemon trees which are succumbing to a gumming disease the station is distributing seedlings and rooted cuttings of them and is working for the production of resistant budded stock. An introduced variety of lemon, which fruited for the first time during the year, is apparently a valuable addition to the present varieties of the island. Many requests have been made of the station for planting material of this variety of lemon and 344 rooted cuttings have been distributed to interested growers.

Most of the Carabao variety of mango trees on the island are either shy bearers or bear only occasionally, unless they are forced to bear by smoking or other methods. The available supply of fruit is not nearly sufficient to meet the present local demand. The Saipan variety is a heavy bearer, but the fruit is decidedly inferior in quality. Seedlings of this variety produce fruit within four to six years after they are planted. A much longer time is required by Carabao seedlings to come into bearing. It is thought that by grafting the Carabao upon Saipan stock a tree can be obtained which will be superior to the ordinary Carabao seedling in prolificacy and early bearing habit. Twenty-one young trees were grafted and distributed during the year and a large number of Saipan seedlings are being grown in the nursery to permit continuation of the work.

A number of excellent varieties of avocados are grown on the island, but most of them ripen during the same season. Varieties which will fruit at different seasons should be introduced for trial, and the inferior types should be replaced with improved kinds. One hundred and seventy-six seedlings which had been grafted to the best local varieties were distributed locally, and a larger number of seedlings are being grown in the nursery and in boxes in the slat house for grafting with local and introduced varieties.

Further studies were made to learn the best methods of controlling scaly bark and gummosis affecting citrus. Bordeaux paste, although not altogether satisfactory, has given the greatest benefit of any of the treatments used so far.

The bananas raised on the island are largely of the inferior so-called Manila variety. This variety is grown to a greater extent than others, probably because it is very hardy and requires little cultivation and also because producers and market venders fail to adver-

tise the better varieties of bananas. Efforts are being made to have the farmers let the public know when they have improved fruits for sale. In order to fill the requests for planting material and to guard against the loss of certain of the varieties which are becoming scarce, the station is growing every variety of banana and plantain found on the island. The Chamorro farmer commonly uses large, well-grown banana plants for " seed " material. A test was concluded during the year comparing the results of planting various types of material. Of all the types used suckers from young clumps gave the largest yield of fruit.

The work with vegetables consists largely in determining the varieties that are best adapted to Guam conditions, introducing and testing crops that are new to Guam, and breeding and selection work with tomatoes.

Formerly all attempts to grow cabbage failed. In some of the plantings all the plants failed to head and in others only a small percentage of heads was produced. Of six varieties tested during the year Centennial Late Flat Dutch gave the highest percentage of heads and the largest total yield. Only the small or " green " varieties of onions are grown locally. Attempts to produce larger types like the Bermuda have not been very successful. The Crystal Wax variety yielded at the rate of 2,700 pounds per acre. Selection work was continued with hybrid tomatoes resulting from crossing the Gulf State Market with the native uba and the Greater Baltimore with the native cherry. The hybrids show improvement in prolificacy over the introduced varieties when grown locally, but are still deficient in size of fruit. Selection work with the Cristobal variety was continued.

Powdery and downy mildews continue to attack curcubitaceous crops, especially cantaloupes and muskmelons. A planting of 12 varieties of introduced muskmelons was sprayed with each of the fungicides, Bordeaux mixture, potassium sulphide, and lime-sulphur. The crop was only slightly attacked by downy mildew, but was heavily infested with powdery mildew. None of the treatments gave any appreciable benefit and the crop was practically a failure.

The station is the only source of seed and plant material. For this reason the introduction and production of seed and propagating material for distribution continues to constitute a comparatively important activity of the station.

In animal husbandry attention continued to be given to the establishment of an improved station herd, upgrading the native stock by the introduction of improved blood (fig. 1), and determining the suitability of rations composed for the most part of locally produced products. The great distance of the island from any source of supply, together with the lack of transportation facilities and the small means of the average farmer, prohibit the general use of imported feeds.

In a feeding test with grade milk cows a local ration of corn and coconut meal compared favorably with an imported mixture composed of oats, corn, bran, and cottonseed meal. A test was conducted with young pigs to demonstrate the inadvisability of placing them entirely on rations of such bulky feeds as breadfruit, papaya, and various root crops. Fresh cassava, coconut meal, and tankage in

combination gave unsatisfactory results when fed to a group of five young pigs. Two groups of young pigs made comparatively good gains on a ration composed of breadfruit,[1] coconut meal, and tankage. A ration made up of 2 parts of cassava and 1 part of coconut meal when fed to brood sows from the time of service until the litter was weaned gave only fairly satisfactory results.

Breeding work with chickens was continued and considerable time was devoted to a study of the internal parasites affecting them. Investigations indicate that parasites are much more prevalent among the chickens than was generally supposed. Ascarids, tapeworms, and to some extent stomach worms, were rather commonly found in the station flocks. Tests were made to compare the anthelmintic properties of carbon tetrachloride and some other similar materials. Feeding *Areca catechu* and papaya seed gave negative results.

FIGURE 1.—Purebred Ayrshire bull raised by the station

Dosages of carbon tetrachloride in coconut oil proved to be efficacious for ascarids and sufficiently so for tapeworms to warrant further study.

The assistant in poultry husbandry cooperated with the department of education by serving as one of the livestock judges at the school fair and as an instructor of the normal-school classes. The quality of stock exhibited at the fair showed improvement over that exhibited in previous years. He also made occasional visits to various ranches and districts where farmers' meetings were held under the supervision of the local commissioners and deputy commissioners. In this connection regular "school meetings" with farmers were held in collaboration with the island government extension agent.

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[1] Breadfruit, or lemae, refers to the fruit of the seedless variety of *Artocarpus communis*. The fruit of the seeded variety is commonly known as "dog-dog."

During the year the entomologist was away from the island on leave of absence from February 9 to April 27. During his absence the work was continued by a native helper under the supervision of the director. The minor insect pests of the island gave very little trouble during the year, but the major pests are threatening factors, only some of which have been reckoned with. Until a few years ago the copra industry was threatened with extinction by the coconut scale, but this is now kept under control by natural enemies. Sugarcane has great possibilities for future development as an important commercial crop now that the sugarcane borer at Togcha, where it was doing much damage, has been brought under control by the Tachinid fly. The sugarcane borer has caused great loss to the sugar industry in other countries, and its control in Guam is considered an outstanding victory. During the latter half of the year the production of the corn-borer parasite (*Exeristes roborator*) was well under way. This parasite is said to be one of the most important of the parasitic insects attacking the corn borer in Europe, and has shown itself amenable to propagation under laboratory conditions. Next to the coconut, corn is the most important crop on the island, and except for some small areas of rice is the only grain grown. It is hoped, therefore, that the parasite will find conditions suitable for development and ultimate control of the borer.

The work with parasites of the house fly and the stable fly is very important from the point of view of the farmer who wants his family and his livestock to be both contented and healthy. This is a matter which might well be measured in terms of dollars, because it means an increase in milk and flesh production in cattle and a decrease in the spread of disease in the community. The relationship between flies and disease is well known and is of special importance in tropical countries where people are commonly affected with bacillary and amoebic dysentery, typhoid fever, or intestinal worms.

ANIMAL HUSBANDRY

CATTLE

The feeding test with milk cows which was begun the latter part of the previous fiscal year was continued. This test is made to compare a local ration consisting of 100 pounds of ground corn and 80 pounds of coconut meal with a ration of imported (with the exception of corn) feeds made up of 100 pounds of corn, 50 pounds of oats, 25 pounds of wheat bran, and 25 pounds of cottonseed meal. At the beginning of the test the local ration consisted of equal parts of corn and coconut meal, but was soon changed because some of the cows at times seemed to object to the high proportion of coconut meal. The two rations were fed alternately for 35-day periods, except in the case of cow No. 134, for which the test periods were of 47 days' duration. In every instance the first five days of each period was considered a preliminary interval and the production for this time was excluded from the tabulations. Throughout the period of the tests the cows were pastured on *Paspalum dilatatum*. They were stabled at night and given, in addition to the grain, coarse green forage, which in amount and kind was substantially the same for each period.

Table 1 gives the results of the test to date.

TABLE 1.—*Effect on milk yield of feeding a local and an imported ration to cows*

Cow No.	Date of calving	Test period	Total number of days in test	Ration	Milk yield: Per ration	Milk yield: Total	Remarks
					Pounds	*Pounds*	
134	1927 Mar. 8	Mar. 24 to May 4	84	No. 1, local	1,103.98	2,174.43	Difference of 158.67 pounds in favor of ration No. 1, local.
		June 26 to Aug. 6			1,070.45		
		May 10 to June 20	84	No. 2, imported.	1,091.61	2,015.76	
		Aug. 12 to Sept. 22			924.15		
50	Sept. 18	Sept. 27 to Oct. 26	120	No. 1, local	686.64	2,314.78	Difference of 85.23 pounds in favor of ration No. 1, local.
		Dec. 6 to Jan. 4			599.37		
		Feb. 14 to Mar. 14			516.45		
		Apr. 24 to May 23			512.32		
		Nov. 1 to Nov. 30	120	No. 2, imported.	635.75	2,229.55	
		Jan. 10 to Feb. 8			568.40		
		Mar. 20 to Apr. 18			526.65		
		May 29 to June 27			498.75		
160	Sept. 8	Sept. 27 to Oct. 26	120	No. 1, local	435.26	1,712.38	Difference of 13.33 pounds in favor of ration No. 2, imported.
		Dec. 6 to Jan. 4			421.86		
		Feb. 14 to Mar. 14			433.07		
		Apr. 24 to May 23			422.19		
		Nov. 1 to Nov. 30	120	No. 2, imported.	421.68	1,725.71	
		Jan. 10 to Feb. 8			446.14		
		Mar. 20 to Apr. 18			435.38		
		May 29 to June 27			422.51		
199	Sept. 28	Oct. 7 to Nov. 5	120	No. 1, local	509.63	1,831.50	Difference of 56.65 pounds in favor of ration No. 1, local.
		Dec. 16 to Jan. 14			475.53		
		Feb. 24 to Mar. 24			430.75		
		May 4 to June 2			415.59		
		Nov. 11 to Dec. 10	120	No. 2, imported.	505.58	1,774.85	
		Jan. 20 to Feb. 18			438.01		
		Mar. 30 to Apr. 28			422.13		
		June 8 to July 7			469.13		
193	Nov. 13	Nov. 22 to Dec. 21	90	No. 1, local	637.91	1,763.94	Difference of 73.99 pounds in favor of ration No. 1, local.
		Jan. 31 to Feb. 29			599.38		
		Apr. 10 to May 9			526.65		
		Dec. 27 to Jan. 25	90	No. 2, imported.	635.78	1,689.95	
		Mar. 6 to Apr. 4			544.22		
		May 15 to June 13			509.95		
213	1928 Jan. 8	Jan. 15 to Feb. 13	60	No. 1, local	489.41	1,029.41	Difference of 46.23 pounds in favor of ration No. 2, imported.
		Mar. 25 to Apr. 23			540.00		
		Feb. 19 to Mar. 19	60	No. 2, imported.	538.07	1,075.64	
		Apr. 29 to May 28			537.57		

Starting the test with the local (No. 1) ration gave it some advantage over the imported (No. 2) ration because of the natural decrease in milk production with the advancement of the lactation period. In continuing the test the cows will be started on the imported (No. 2) ration. The two rations used do not differ materially with respect to total percentage of protein. One pound of grain was allowed per 2 pounds of milk produced in instances where the daily yield was not over 16 pounds. When the daily production exceeded this amount the grain allowance was approximately 1 pound per 2.5 pounds of milk. The cost of the local ration averaged approximately 2 cents and that of the imported ration 3 cents per pound.

SWINE

Breadfruit, cassava, and coconut for young pigs.—Local farmers commonly feed their pigs rations that are altogether too bulky, especially for young, growing stock. The feeds are fed singly and in combination, and include cassava, yams, fresh coconut, taro tops and small roots, breadfruit, and papaya. In order to demonstrate the inadvisability of feeding such rations to young pigs, a litter of weanling grade pigs was fed for a period of 60 days a ration composed of equal parts by weight of breadfruit, cassava, and fresh

coconut. The lot in addition was fed fresh Para grass twice daily and was kept in the swine house. The litter was borrowed from a neighboring rancher for testing. Some of the pigs were in poor condition when they were received. Three of the litter died, two failed to make any appreciable gain, and each of the others made an average daily gain of only 0.2 pound. The results indicate that bulky rations, such as those mentioned above, are not satisfactory for young pigs even when they are allowed free range.

Tests were continued in the hope of finding swine rations which will be an improvement over those now in general use and can be fed by the farmer of small means.

Cassava, coconut meal, and tankage for young pigs.—Five grade female pigs (litter mates) about 4 months old were fed for a period of 70 days a ration composed by weight of 2 parts fresh cassava, 1 part coconut meal, and 2 ounces of tankage per head daily. The lot, in addition, was given fresh Para grass twice daily and was confined to the swine house and a small dry run. The lot made a total gain of 133 pounds, or an average daily gain of 0.38 pound per head. The pigs had been fed a rather unsuitable ration from time of weaning to time of placing on test, and, although in fair flesh, they showed a lack of proper development. Notwithstanding this fact, the decidedly low gains made indicate that the ration as used is unsatisfactory for pigs of the age of the animals tested.

Breadfruit, coconut meal, and tankage for young pigs.—Seven female grade pigs 70 days old were turned on Para grass and fed for a period of 65 days a ration composed of equal parts by weight of coconut meal and cooked breadfruit. They received in addition 1 ounce of tankage per head daily. The lot made a total gain of 373 pounds, or an average daily gain of 0.82 pound per head. The cost of the feed per 100 pounds of gain, exclusive of pasturage, was $3.78.

The test was repeated with a lot of five female grade pigs 77 days old. During a period of 80 days this lot made a total gain of 320.5 pounds, or an average daily gain of 0.8 pound per head. The cost of the feed, exclusive of pasturage, per pound of gain was $0.04.

The results of the above-mentioned and earlier tests indicate that the kinds of rations commonly fed young pigs could be improved by the addition of coconut meal and a small amount of tankage.

Coconut meal and cassava for brood sows.—During the year three sows were used in the series of tests which were begun the year previous. From time of service until time of farrowing the sows were fed a ration composed of 2 parts fresh cassava and 1 part coconut meal, and from time of farrowing until time of weaning the litter each sow received in addition 2 ounces of tankage daily. One sow was in poor flesh at the time the litter was weaned and the other two sows were in only fair condition. More favorable results were obtained in the test of the year previous, when coconut meal and cassava in equal amounts were fed to the sows.

REPORT OF THE ASSISTANT IN POULTRY HUSBANDRY

F. B. Leon Guerrero

BREEDING WORK

Previous work had shown that the Single Comb Rhode Island Red × native (G. S. No. 11) cross was well adapted to local conditions. It was decided to attempt the development of a new variety with this cross, the foundation stock of which had been well selected on both sides. A variety is desired having solid white plumage, yellow skin, single combs, slightly smaller size than is the standard requirement for Rhode Island Reds, and combining the egg-laying qualities and compact type of this parentage with the hardiness of the native. The native foundation stock consisted of single-comb white hens having either white or yellow skin. First matings within the cross were made in October, 1920. Difficulty was encountered in establishing solid-white plumage and white-egg characters, however, and it was therefore decided to introduce a cross of some white-plumaged white-egg breed. After a few trial matings of Single Comb White Leghorns to Single Comb Rhode Island Reds × natives proved to be satisfactory, reciprocal crosses were made. (Fig. 2.) The progeny resulting from these matings are solid white in plumage except for a color defect on the wings and back of some of the individuals. At the close of the year the pullets from the first hatches began to lay. (Fig. 3.)

Figure 2.—Rooster of a cross of White Leghorn × Rhode Island Red × native

FEEDS AND FEEDING

Tests were begun to determine the comparative palatability and feeding value for growing chickens of such locally grown feeds as corn, fresh cassava, cowpeas, and coconut meal, but had to be discontinued when it was discovered that the flock had chicken pox and was heavily infested with intestinal parasites. Five lots of chicks were used in the tests. Corn ranked highest of the feeds in palatability, and was followed by cassava, coconut meal, and cowpeas, in the order named.

Cod-liver oil for chicks.—Results of further tests substantiate those obtained last year in showing that chicks confined indoors

during the rainy season may be kept free from leg weakness by adding cod-liver oil to the ration.

NOTES ON DISEASES, AILMENTS, AND PARASITES

An unusually heavy infestation of intestinal parasites in the station flocks makes the problem of disease control more complicated than it has been for some time. This is true especially of young and growing stock which is affected with intestinal parasites, colds, and chicken pox in combination. Colds appear in most instances in exposed chickens which are in a run-down condition, and for this reason can be easily controlled. Parasites may be controlled by the use of proper anthelmintics, but this point is being further studied. The type of chicken pox generally present locally, unless complicated by the presence of some other disease, can be controlled, provided that the victims are not too young. Treating the latter kind of stock with mercurochrome seems to be better than treating with iodine, probably because the former has a milder effect on the sensitive tissues than has the latter.

FIGURE 3.—Pullet of a cross of White Leghorn × Rhode Island Red × native

USE OF ANTHELMINTICS FOR INTESTINAL PARASITES

The presence of intestinal parasites in the station flock is a serious menace to its proper development, especially in the case of the young stock. Severely infested chicks under 12 weeks of age seldom survive. Chicks under 6 weeks of age were found to be heavily infested with both tapeworms and roundworms. Stomach worms also were prevalent. Of the different kinds of anthelmintics tried, carbon tetrachloride in fresh coconut oil proved to be the most effective. A lot of ninety 10-weeks-old chicks was used in the preliminary test. Mortality was very high in the flock before treatment was given, and when treatment was begun many of the chicks were partly crippled and all were more or less emaciated. The use of carbon tetrachloride in oil (1 part to 3 parts fresh coconut oil) stopped further losses and within a week the crippled lot was apparently restored to normal. The dosage used varied from 3 to 9 cubic centimeters of the drug and oil combination.

Tests were made to determine the efficacy of different anthelmintics. The chickens used were confined in small crates having 1-inch wire mesh bottoms. (Fig 4.) Receiving pans were placed under each crate and were changed at intervals to permit examination of all fecal matter for the presence of parasites and their eggs. The entomologist of the station materially assisted in making microscopic examination of the fecal matter.

Test No. 1. Freshly ground betel nut (*Areca catechu*).—Six chicks of the same age, sex, and breeding were used in the test. Freshly ground betel nut was forcedly fed to each chick at 5.30 p. m., and was followed the next day by a purgative. Separate examination was made of the feces dropped before treatment and after the purgative became effective. Chicks Nos. 1 and 5 were dosed at the rate of 250 milligrams per kilo of body weight. Before the purgative was administered tapeworm segments and ova were found in the fecal samples from chick No. 1 and ascarid ova in those from chick No. 5. Postpurgative examination of the feces after seven hours proved to be negative,[2] whereas post-mortem examination of chick No. 5 revealed the presence of 2 living ascarids and 3 living tapeworms. Chicks Nos. 4 and 6 were each dosed at the rate of 500 milligrams per kilo of body weight. Prior to purgation two complete tapeworms were found in the fecal samples from chick No. 4, and the fecal samples from chick No. 6 proved to be positive and from chick No. 4 negative for ascarid ova. Both chicks expelled tapeworm segments. Postpurgative examination of feces seven hours later showed the

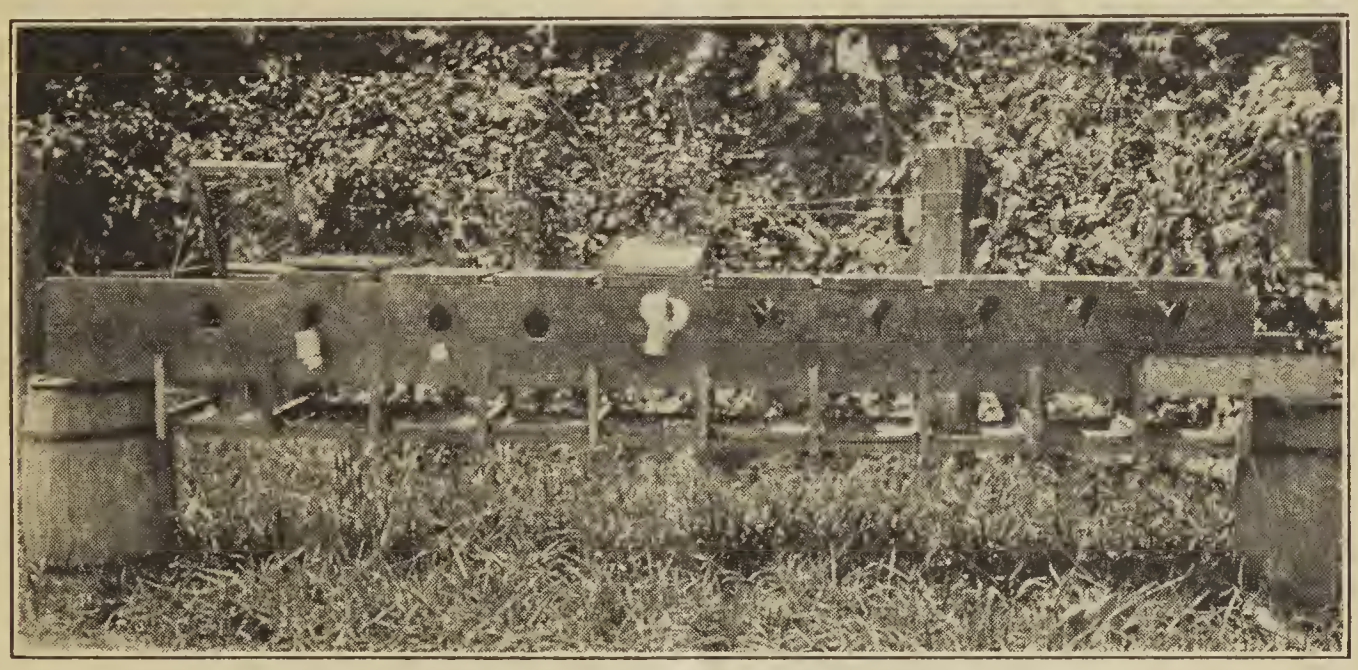

FIGURE 4.—Coop used in anthelmintic tests with chickens

presence of 1 ascarid and 2 tapeworms in the feces of chick No. 6, but none in the feces of chick No. 4. Post-mortem examination of chick No. 6 at this period revealed the presence of 9 living ascarids, 18 living tapeworms, and 11 living stomach worms. Chicks Nos. 2 and 3 were each dosed at the rate of 1,000 milligrams per kilo of body weight. This dosage proved to be even less efficacious than the smaller doses, which indicates that freshly ground betel nut is unsatisfactory when used alone as an anthelmintic for chickens. Temporary partial strangulation during the forced feeding process was the only ill effect resulting from this treatment.

Test No. 2. Freshly ground Carica papaya seed.[3]—Six chicks of the same age, sex, and breeding were used in this test. Freshly ground papaya seed was fed to each chick at 5.30 p. m. and was followed at 5.30 a. m. the next day by a purgative. Separate examination was made of the feces dropped before and following purga-

[2] The terms "positive" and "negative," as here used, refer to the results found through microscopic examination of feces, except where otherwise stated.

[3] Freshly macerated seed of *Carica papaya* is claimed by the Chamorros to have anthelmintic properties for ascarids in human beings.

tion. Chicks Nos. 2 and 5 were dosed at the rate of 500 milligrams per kilo of body weight. Prior to purgation chick No. 2 expelled tapeworm segments. Postpurgation examination of the feces after seven hours proved to be positive for both tapeworms and ascarids. Chick No. 2 expelled 1 ascarid and 3 tapeworms. Post-mortem examination of chick No. 5 revealed the presence of 15 living ascarids and 10 living tapeworms. Chicks Nos. 3 and 6 were dosed at the rate of 1,000 milligrams per kilo of body weight. Prior to purgation chick No. 3 expelled 3 stomach worms and chick No. 6 1 tapeworm. Both chicks were positive for tapeworm segments and ascarid ova. Postpurgation examination seven hours afterwards showed that chick No. 6 was negative and chick No. 3 was positive for tapeworm segments and both chicks were positive for ascarid ova. Post-mortem examination of chick No. 3 revealed the presence of 60 living ascarids and 23 living tapeworms and 8 apparently dead stomach worms. Of the latter number 6 were detached from the stomach wall and were still inside the stomach and 2 were near the anterior cloaca opening. Chicks Nos. 1 and 4 were dosed at the rate of 1,250 milligrams per kilo of body weight. Prior to purgation chick No. 4 expelled 3 ascarids and 2 tapeworms and both chicks were positive for tapeworm and ascarid ova. Postpurgation examination after seven hours showed that the chicks were positive for tapeworm segments and negative for ascarid and stomach worm ova. Post-mortem examination of chick No. 1 revealed the presence of 32 living tapeworms and 1 living ascarid.

Test No. 3. Carbon tetrachloride thoroughly mixed with fresh coconut oil.—This test was divided into three parts according to the different methods of handling before treatment, the strength of the dosage administered, and the relation of dosage to body weight.

Group A received, independent of body weight, varying dosages of a solution of 1 part carbon tetrachloride to 2 parts of coconut oil. They were full fed to time of treatment at 8 a. m. Epsom salts was given at 10 a. m. and the chicks were posted at 1 p. m. of the same day. No worms were expelled from time of treatment to time of posting. Chick No. 1, weighing 421 grams, was given 6 cubic centimeters of the solution. Post-mortem examination showed the presence of 6 living ascarids and 16 dead whole tapeworms in addition to many tapeworm segments. Chick No. 2, weighing 600 grams, was given 8 cubic centimeters of the solution. Post-mortem examination revealed the presence of 5 dead and 9 living ascarids and 6 apparently living tapeworms. Chick No. 3, weighing 518 grams, was given 10 cubic centimeters of the solution. Post-mortem examination showed the presence of 5 dead ascarids.

Group B received varying dosages per 100 grams of body weight of a solution of 1 part carbon tetrachloride to 3 parts of coconut oil. The birds were fasted for 20 hours previous to receiving the solution at 8 a. m. and were given salts at 10 a. m. Feces were examined at 12 noon and again at time of posting at 5.30 a. m. of the following day. Chick No. 1 was given 3 cubic centimeters of the solution per 100 grams of body weight. Fecal examination four hours after treatment and two hours after purgation showed the presence of 12 ascarids and 14 tapeworms. Fecal examination at time of post-mortem 22 hours after treatment showed the presence

of 5 ascarids and was positive for tapeworm segments. No worms were found in the post-mortem examination. Chick No. 2 was given 1.5 cubic centimeters of the solution per 100 grams of body weight. Fecal examination four hours after treatment and two hours after purgation showed the presence of 2 ascarids and 25 tapeworms. Fecal examination at time of posting showed the presence of 11 ascarids and 3 tapeworms. Post-mortem findings revealed the presence of 7 dead and 1 living tapeworm, 34 dead stomach worms, and 4 dead ascarids. The latter were found in the crop and may have been swallowed after they were expelled. Chick No. 3 was given 2 cubic centimeters of the solution per 100 grams of body weight. Fecal examination four hours after treatment and two hours after purgation showed the presence of 1 tapeworm and many tapeworm segments. Fecal examination 22 hours after treatment showed the presence of 2 tapeworms and many tapeworm segments.

Group C, consisting of a pullet, a cockerel, and a cock, was given doses of 1 cubic centimeter each of a varying solution of carbon tetrachloride in coconut oil. The birds were fasted for 21 hours before receiving the treatment at 9 a. m. and were given a purgative at 1 p. m. Feces were collected for examination at the time of purgation and at 5.30 a. m. of the following day, when all were posted. The pullet, weighing 315 grams, was given 1 cubic centimeter of a solution of 1 part carbon tetrachloride in 2 parts of fresh coconut oil. Prior to purgation it expelled 16 tapeworms and was found to be positive for ascarid ova. Postpurgation examination of feces 20 hours after treatment showed the presence of 18 dead ascarids and 2 dead tapeworms. Post-mortem examination revealed the presence of 1 dead and 18 living stomach worms, the latter having their head parts still buried in the mucosa of the stomach wall. No tapeworms or ascarids were found. The cockerel, weighing 560 grams, was given 1 cubic centimeter of a solution of 1 part carbon tetrachloride in 3 parts of fresh coconut oil. Fecal examination showed positive for tapeworm segments and negative for ascarid ova. Post-mortem examination revealed the presence of 1 living tapeworm and 5 dead ascarids, of which 4 were in the crop and 1 was near the vent. The cock, weighing 1,400 grams, was given 1 cubic centimeter of a solution of 1 part carbon tetrachloride in 2 parts of fresh coconut oil. This bird had been sick for some time previous, being unable to turn around without falling over. It had been treated with carbon tetrachloride once every two weeks for one month before the test was begun, and showed much improvement until shortly before the last week, when it gave indications of relapsing. Prior to purgation the bird expelled 2 tapeworms, and fecal examination showed the presence of aesophagal worm ova. The cock improved greatly after it was treated and was posted 19 days after treatment, when it was found to be free from tapeworms and ascarids but to harbor a number of stomach worms.

Comments.—From these trials it is safe to conclude that freshly ground betel nut is the least satisfactory of the anthelmintics used. Carbon tetrachloride in coconut oil administered after a short fasting period was efficacious for ascarids and in some instances was of considerable benefit against tapeworms.

PUBLIC STOCK-IMPROVEMENT WORK

In the work of improving the poultry industry of the island 97 dozen eggs for hatching and surplus breeding stock were distributed to local poultry raisers.

REPORT OF THE ASSISTANT IN AGRONOMY AND HORTICULTURE

By JOAQUIN GUERRERO

FORAGE CROPS

A large part of the interior of the island of Guam is rugged or hilly in topography. The open or savanna areas are covered principally with sword grass (*Miscanthus floridulus*), while less extensive areas support several varieties of short bunch grasses. These uplands are utilized almost exclusively for pastures. Except for their low carrying capacity, especially during the dry season, they are fairly satisfactory for carabao and the native cattle, but are for the most part unsuitable for improved cattle. From time to time the station has given attention to methods of improving these pastures. *Paspalum dilatatum* has been found to make satisfactory growth on certain of the sword-grass areas when the land, previous to being planted, is either plowed, or cleaned with the fosiño, and cultivation is occasionally practiced until the crop is well established. However, these methods of planting are expensive and some of the upland areas are so stony as to make cultivation impossible.

A test was begun September 10, 1927, on a half-acre area of rocky, limestone hilltop, where the elevation is probably 150 feet and there is little surface soil, to determine the possibility of growing *P. dilatatum* on soil receiving no preparation other than that of cutting back the sword grass. Root divisions of Paspalum were used for the purpose, being planted 18 inches apart in rows 4 feet apart. The only cultivation given the plat during the year was that of cutting back the sword grass four times. The cut grass was placed between the rows of Paspalum to aid in suppressing successive growth and to furnish additional soil material and conserve moisture. At the close of the year the Paspalum covered about one-third of the plat and was ready for pasturing. Behavior of the crop indicates that under similar conditions the rows should be made closer than was done in this instance.

The most troublesome pests in the station pastures are the shrub locally known as aroma (*Acacia farnesiana*) and the weeds *Cassia occidentalis* and *Hyptis capitata*. In a study of methods of destroying these pests it was observed that one dense plat of aroma was killed by the parasitic vine, maiagas (*Cassytha filiformis*), which in turn was then easily destroyed by burning. Growing maiagas among areas of aroma would therefore seem to offer a possible means of destroying it, but efforts to propagate the parasitic plant by seed have so far failed.

Effect of ground limestone (cascajo), burnt lime (local), and coconut cake on yield of Napier grass.—This test, begun July 15, 1925, and conducted mainly for the purpose of comparing the relative efficiencies of cascajo and lime as fertilizers for Napier grass,

was discontinued because of a gradual decrease in the stand of the grass. The test also included one plat to which copra meal was applied. The work was done on poorly drained, heavy lowland clay soil which for a number of years previously had been devoted to Paspalum and used as a paddock. Although no indication of disease or other trouble was apparent in the growing stalks, portions of the hills or clumps were found dead from some unknown cause after each cutting. Lack of drainage was first thought to be the cause of the trouble, but observations with plantings at the Barrigada farm, where drainage is very good, showed them also to be similarly affected. Lack of fertility was thought to be responsible for the trouble at the latter place, but this opinion was held untenable because the field on which the crop was grown at the station was very fertile. The plat receiving the ground cascajo showed less trouble than did the other plats. The plat receiving white cascajo produced the highest yield and was followed by the plats receiving coconut meal, lime, and no treatment, in the order named.

Table 2 shows the effect of fertilizer on yield of Napier grass.

TABLE 2.—*Effect of fertilizer on yield of Napier grass*

Date of cutting	Yield per acre when treated with—			
	Lime	Coconut cake	No treatment	White cascajo
1926	*Tons*	*Tons*	*Tons*	*Tons*
Jan. 26	8.190	7.335	6.885	11.160
June 2	5.985	5.805	5.220	5.850
July 15	4.995	4.770	3.965	4.973
Oct. 27	4.073	4.433	3.713	6.143
1927				
Jan. 13	1.823	3.015	1.260	4.545
Mar. 30	1.980	2.543	1.800	4.680
June 30	4.657	4.252	3.465	4.545
Oct. 25	1.507	1.327	1.057	3.172
Total	33.210	33.480	27.365	45.068

Effect of fertilizer on yield of Japanese cane, Napier grass, and Guatemala grass.—This test, begun October 25, 1923, comparing the effect of lime, manure, and lime and manure in combination on yield of Japanese cane and Guatemala and Napier grasses, was completed during the year except for later observations on the residual effects of the fertilizer applications. A summation of results shows that the Japanese cane and the Guatemala grass each produced 9 and the Napier grass 10 cuttings. In the case of all three of these forages the plat receiving barnyard manure alone produced the second highest yield of forage. The plat receiving lime and manure in combination gave the highest, and the plat receiving lime alone the lowest yield in the case of the Japanese cane and the Napier grass, whereas with the Guatemala grass the reverse was true, the lime plat producing the best results. The results of this test are contradictory regarding the reputed inadvisability of using manure and lime in combination. The lime used was locally produced from coral limestone. The material had been exposed to the weather for some time before it was used and was no doubt very slow in acting. The

area on which the test was conducted showed a high degree of uniformity throughout, as was indicated by previous crop growth during a number of years.

Complete results of the test are shown in Table 3.

TABLE 3.—*Effect of fertilizers on yield of Japanese cane and Guatemala and Napier grasses*

Date of cutting	Yield from treatments given—								
	Japanese cane			Guatemala grass			Napier grass		
	Lime	Manure	Lime and manure	Lime	Manure	Lime and manure	Lime	Manure	Lime and manure
	Tons	*Tons*	*Tons*	*Tons*	*Tons*	*Tons*	*Tons*	*Tons*	*Tons*
1924									
Mar. 29							12.0	8.5	12.5
May 23	16.2	15.4	25.0	8.0	9.2	6.2			
July 18							15.5	13.5	22.5
Dec. 8	19.0	18.5	16.0	17.5	14.0	13.0	7.0	10.0	11.5
1925									
July 16	22.7	27.2	26.7	11.8	12.5	13.7	18.7	22.8	24.0
Nov. 24	9.0	10.0	12.0	11.0	9.5	8.0	10.0	6.5	7.0
1926									
June 8	17.0	16.0	14.0	7.5	6.0	4.5	14.0	11.0	12.0
Aug. 31	9.0	14.0	9.0	15.0	12.0	9.5	16.0	14.0	17.0
1927									
Jan 29	10.5	22.0	13.5	11.5	9.0	10.5	10.5	13.0	10.5
June 17	7.0	6.0	11.0	7.0	7.0	8.0	12.0	16.5	16.5
Nov. 18	7.0	5.5	9.0	11.0	8.5	11.0	7.0	9.0	9.0
Total	117.4	134.6	136.2	100.3	87.7	84.4	122.7	124.8	142.5

Further studies of the behavior of the three leading coarse forages—Napier grass, Guatemala grass, and Japanese cane—show that on lowland clay soil Guatemala grass is better able to withstand competition with other grasses and weeds than is either Napier grass or Japanese cane. In a planting made October 29, 1921, on an area where clean cultivation has not been practiced for four years, the entire stand of Japanese cane and about half the stand of the Napier grass plat have been killed by Para grass, native grasses, and weeds, whereas the stand of Guatemala grass still is fairly good.

Adaptability tests with coarse forages.—The principal introduced coarse forages have been found to be well adapted to the lowland clay areas. Trials are being carried on to show the degree of suitability of the grasses to other soils, especially to the thin uplands which are underlain by limestone. In this series of tests begun in November, 1924, a limestone hillside at the station where the soil resembles some of the poorer soils of the northern part of the island has been used for plats of Japanese cane, Napier grass, Guatemala grass, Merker grass, and *Pennisetum setosum.* To date the Japanese cane has produced seven and each of the others nine cuttings. So far the Napier grass has given the highest average yield per cutting and the Japanese cane the lowest.

LEGUMES

Cowpea variety test.—Greater local interest has been shown in the cowpea than in the other cover crop and forage legumes which have

been introduced by the station, probably because of the double value of the cowpea as a food for human consumption and as a green manure. Under local conditions it would seem advisable to grow a variety of cowpea, which will not only supply a fairly good amount of seed and foliage but also aid materially in improving the soil. To determine the comparative suitability of different varieties for the purpose, the seed of seven varieties was obtained from the United States Department of Agriculture and planted December 31, 1927. A poor stand resulted in a number of instances and necessitated replanting. The plats were harvested in March, 1928. Conch gave the highest grain yield of the varieties and was followed by S. P. I. No. 64017, Progressive, White Queen, Hawaiian Hybrid, S. P. I. No. 46175, and S. P. I. No. 46373, in the order named. The Conch variety also showed good cover-crop characteristics. Progressive and White Queen made the poorest showing in this respect. The work has not progressed sufficiently as yet to permit drawing definite conclusions.

Pigeon peas (*Cajanus indicus*).—The green-manure and cover-crop test with pigeon peas, begun January 9, 1926, was terminated because many of the plants died during the rainy season from an apparent lack of drainage. In the test as planned the plants are topped at intervals, the material is placed between the rows to decompose, and efforts are made to learn the effect of the method upon the texture and fertility of the soil. The test is to be resumed in a more favorable location.

The planting of pigeon peas made April 16, 1927, was topped (about one-third of the height of the plants) May 31, 1928, and gave a yield of 9.6 tons per acre. It was found that care should be exercised as to the period at which topping is made. Topping was done during the period of light rainfall and many of the plants having a trunk diameter of 1 inch or more died afterwards, whereas the more slender of the plants put out satisfactory new growth. At the time of topping all the plants had reached a comparatively uniform stage of maturity, as was indicated by the fruiting.

In tests of pigeon peas intercropped with corn the latter produced 5,970.6 pounds of ear corn per acre and the pigeon peas grew luxuriantly and did not seem to be adversely affected by the corn.

Cover-crop efficiency test.—In this work, begun during the fiscal year of 1924, various legumes are being grown to determine their comparative value as a cover crop. Data are being kept on the cost of growing each crop and the length of time it efficiently suppresses weed growth. During the year the Black Mauritius and the Alabama varieties of velvetbeans and the Hawaiian hybrid cowpea were included in the test. Two cultivations were necessary in all instances before the vines began to overlap between rows. The cowpeas efficiently covered the area in 64 days from time of planting, the Alabama velvetbean in 84 days, and the Black Mauritius velvetbean in 94 days. Of the three crops the Black Mauritius velvetbean made the densest and most efficient cover crop. A few scattering weeds were present in the plats of the Alabama velvetbean and the cowpea. The latter began to decrease in value as a cover crop immediately following the first harvest of grain. At the close of the year the two varieties of velvetbeans were still satisfactorily covering the ground.

CEREAL CROPS

Adlay (*Coix lachryma-jobi*).—In continuation of the adaptation test, begun in December, 1922, with the paper or thin-shelled adlay, the seed of seven varieties was introduced from the Philippines during the year for trial. Only four of the varieties germinated. Batanges gave the highest yield. All the plats have been cut back for the production of a ratoon crop.

Rice (*Oryza sativa*).—The low yields of rice throughout the island are attributed in part, at least, to the need of new seed. Introductions of seed from the Philippines were again made during the year. Of the varieties introduced, Ramai, Inachupal, and Mancasar gave the best results. In all cases reported or investigated the introduced varieties produced yields much above the yield of the native rice.

ROOT CROPS

Sweetpotato (*Ipomœa batatas*).—In continuation of the variety test, comparing the yields of imported and native varieties of sweetpotato, a planting of both kinds was made November 12, 1927, and harvested April 20, 1928. Five of the introduced varieties were obtained from the Hawaii experiment station. They had been produced from seed. The introduced varieties gave the following estimated acre yields: Nancy Hall, 5,150 pounds; Yellow Jersey, 5,108 pounds; Porto Rico, 4,800 pounds; and the five Hawaiian varieties, 9,050, 7,750, 4,350, 1,300, and 1,300 pounds, respectively. The native varieties gave the following estimated acre yields: Yap, 9,250 pounds; Patas Ñgañga, 4,150 pounds; and Dago, 950 pounds. The native varieties, especially the Yap, are decidedly inferior in quality to the leading introduced varieties.

Edible canna (*Canna edulis*).—In certain localities interest in edible canna as a food crop is gradually increasing, due principally to the facts that the crop can be grown on upland areas where taro can not be grown and seems to be less susceptible to damage by the Egyptian cotton worm (*Prodenia litura*) and the leaf hopper (*Megamelus* sp.) than is taro. In order to meet the increasing demand for seed material, a new planting was made November 15, 1927, and harvested June 30, 1928. It yielded at the rate of 15,807 pounds of tubers per acre.

Taro.—A planting each of the native taro and an introduced variety of yautia made March 15, 1927, was harvested in January and March. The taro yielded at the rate of 13 tons and the yautia at the rate of 16 tons per acre. This variety of yautia was introduced into Guam by the station many years ago, but failed to attract attention until recently. It not only outyields the local taro but also is apparently less damaged by insect pests. The variety is being distributed throughout the island and many now prefer it to the local taro.

Cassava (*Manihot utilissima*).—A planting of the white cassava made March 17, 1927, and harvested March 12, 1928, yielded at the rate of 15.5 tons per acre.

FRUIT INVESTIGATIONS

Citrus.—One of the lemon trees which was introduced through the United States Department of Agriculture as *Citrus limonia* and planted at the station October 2, 1922, fruited for the first time during the year. The fruit is exceptionally large, very juicy, and has an occasional seed. (Fig. 5.) The flavor does not equal that of the best lemons grown in the States, but the variety is popular locally because of its prolificacy and the size and juiciness of the fruit. The demand for propagating material has been much greater than the supply. The tree is low growing or bushy in habit, and fruits more or less continuously, producing flowers and fruit in all stages of development at the same time. It is easily propagated either by ordinary cuttings or by layering.

Further studies were made to learn the best methods of controlling scaly bark (psorosis), gummosis, and the tineid leaf miner, all of

FIGURE 5.—Fruit of *Citrus limonia*

which attack citrus trees. The two former are serious throughout the island. The leaf miner, although very prevalent, does not apparently seriously damage older trees, but materially retards the growth of nursery stock. Scraping the infected area and applying Bordeaux paste to the wound, while not entirely satisfactory, has proved to be the most effective of the remedies tried for scaly bark and gummosis. Frequently applying the paste to the trunks of healthy trees appears to be beneficial as a preventive of these diseases. No satisfactory control has as yet been found for the leaf miner.

Ceriman (*Monstera deliciosa*).—The ceriman, another introduction, bore fruit for the first time. (Figs. 6 and 7.)

Avocados.—In connection with the production of grafted avocados for distribution, work was begun to determine the best method of propagating the tree. The one comparative test completed during the year included the splice, the cleft, the bottle, the side-tongue, and the whip methods of grafting. Of these the splice method gave the

highest percentage of union, followed by the other methods, in the order mentioned.

Pineapples.—In order to meet, in part at least, the increasing demand for propagating material of improved pineapples, the area devoted to the Smooth Cayenne and the Thorny Red varieties was extended, about 1 acre being added during the year.

Bananas.—During the year a start was made on a collection, for observation and for the production of propagating material for distribution, of all the different varieties of bananas and plantains now found growing on the island.

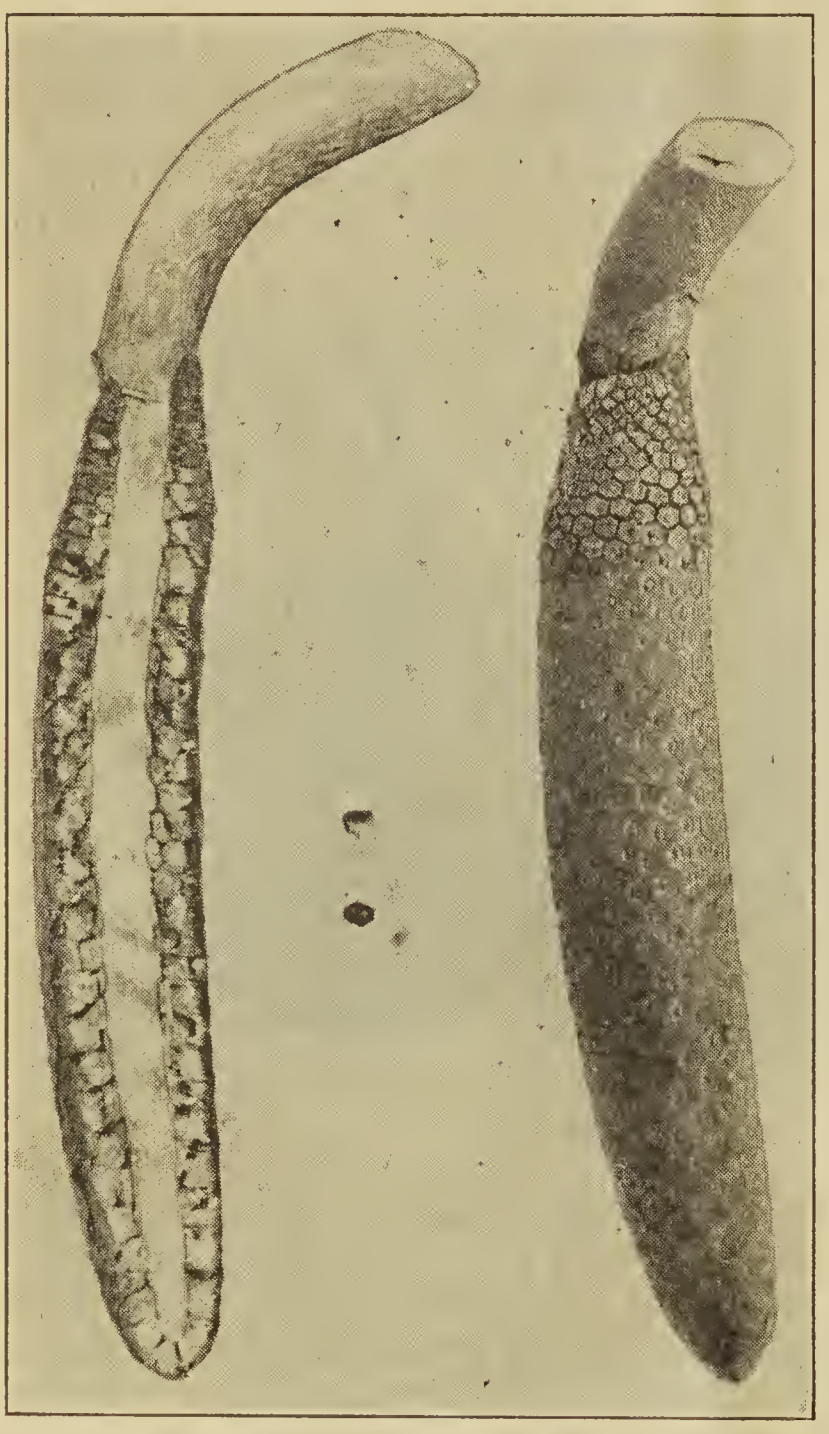

FIGURE 6.—Fruit of ceriman (*Monstera deliciosa*)

In growing bananas the local farmers commonly use older stalks or plants about one-half to two-thirds grown for propagating material. In order to determine and to demonstrate what kind of material is most suitable for planting, a planting of the common Manila variety of bananas was made October 1, 1924. Plants of various types and in various stages of growth were used, including sword-leaf and round open-leaf suckers from young clumps, suckers from 1 to 2 year old clumps and from aged clumps, stalks one-half to two-thirds grown with top intact, and stalks pruned to within 1 foot of base and others with top only pruned. The planting was made on a heavy clay lowland of poor texture and fertility; consequently, the yields were low. However, the location is unusually uniform in soil characteristics and the plat yields should therefore be comparable. Both types of suckers from young clumps gave a yield considerably above that of all the other kinds of seed material used. Of these two the sword-leaf type ranked first in production. Suckers from 1 to 2 year old clumps were next in yield, followed by those from aged clumps. The stalks set out with whole top or leaves intact were the first to bear fruit, the first harvest being made about eight months after date of planting. They also gave the highest yield of the older-stalk plantings and were followed closely by the stalks with pruned tops.

FIGURE 7.—Plant of ceriman (*Monstera deliciosa*)

GARDEN-VEGETABLE DEMONSTRATIONS

Cabbage.—The production of head-producing strains seems to be the main consideration in cabbage growing in Guam. Some varieties fail to head at all, some give a small percentage of heads, and a few others give satisfactory results. Behavior of the crop in this respect seems to be dependent upon the source of the seed. In a number of instances seed produced in the southern United States has given much better crops than has northern-grown seed.

Six varieties of cabbage were planted September 30, 1927, and harvested February 13, 1928. Centennial Late Flat Dutch produced the highest percentage of heads, 91.6 per cent, and was followed by All Seasons with 88.4 per cent, Florida Drumhead with 83.8 per cent, Genuine Surehead with 83.3 per cent, Long Island Wakefield with 81.8 per cent, and Sure Crop with 76.4 per cent, in the order named. In size of heads Centennial Late Flat Dutch ranked first, with Florida Drumhead closely following.

A twentieth-acre plat was planted with the All Seasons variety November 2, 1927, and harvested March 23, 1928. The planting yielded 551 pounds, which was at the rate of 5.51 tons per acre. A few ranchers are showing an interest in this new crop. Those who secured seeds of the variety at the beginning of the fiscal year reported good results from their plantings and requested more seed for use the following season.

Onions.—The two varieties of onions raised locally are of the class commonly known as shallots and are useful only as "green onions," or for pickling. Many attempts to grow the larger varieties of onions have failed. Guam conditions are similar to those of some of the tropical countries where this type of onion is successfully produced, and it would therefore seem that a variety might be found which would be adapted to the local environment.

A planting of the Crystal Wax variety made December 24, 1927, and harvested May 4, 1928, yielded at the rate of 2,700 pounds per acre. Approximately 5 per cent of the bulbs decayed in the ground before the crop was ready to harvest. The average weight per bulb was 4 ounces.

Tomatoes.—Many different varieties of tomatoes from the States have been tested by the station, but none has proved to be entirely satisfactory. Some of them were lacking in size and quality of fruit, but most of them were lacking in prolificacy. These defects have been increasingly apparent in successive crops of tomatoes grown from locally-produced seed.

In the breeding work with tomatoes, the third-generation hybrids, resulting from crossing Gulf State Market with the native uba and Greater Baltimore with the native cherry, have been harvested. These crosses are again satisfactory with respect to prolificacy, but are lacking in size of fruit. Selective breeding with these hybrids and with the local Cristobal variety is being continued.

Control of mildew.—Powdery and downy mildews are the most serious local diseases of curcubitaceous crops. Muskmelons, particularly the imported varieties, are attacked by these fungi. To permit continuation of studies of the best control measures, 12 imported varieties of muskmelons were planted December 23, 1927. Comparative plats of each variety were treated with potassium-

sulphide, lime-sulphur, and Bordeaux-mixture sprays. Treatment was begun at about the time the plants started to trail, before the presence of disease was apparent, and repeated weekly. Throughout the test period the trouble was confined almost entirely to the powdery type of mildew. It was especially severe and yielded to none of the treatments. The crop in each case was practically a failure.

SEED AND PLANT DISTRIBUTION

During the year general distribution included 2,056 packets and 15 pounds of vegetable seeds, 109 packets of papaya seeds, 29 packets of seeds of ornamentals, 1 sack of narra seeds, 35 pounds of Egyptian wheat, 31 pounds of seed rice, 37 pounds of cowpeas, 262 papaya seedlings, 2,299 rooted ornamental plants, 82 breadfruit plants, 56 pili plants, 176 grafted avocados, 267 miscellaneous economic plants, 1,050 taro plants, 265 santol plants, 208 mahogany plants, 882 tangerine plants, 172 mabolo plants, 350 Isabella grape rooted cuttings, 4 sacks of miscellaneous grasses, 168 pineapple suckers, 344 rooted lemon cuttings, 602 lettuce plants, 2 sacks of sweetpotato vines, 21 grafted mangoes, 96 orange plants, 244 pepper plants, 206 eggplants, 614 tomato plants, and 56 lumbang plants.

REPORT OF THE ENTOMOLOGIST

S. R. VANDENBERG

THE SUGARCANE BORER

The sugarcane borer (*Rhabdocnemis obscura*) is generally present in the cane fields of the island and does serious damage to them when the cane reaches commercial size. The borer also attacks the bud tissue of the coconut palm to a limited extent and lately has been found established in the bole or lower portion of the trunk of the coconut, where it produces symptoms similar to those of the so-called "bleeding disease." It seems almost incredible that this insect, the primary host of which is supposed to be the succulent sugarcane, can find conditions suitable for its development in the coconut trunk; yet the borer in all stages except that of the egg was found in this semisolid wood. The burrows did not penetrate into the wood beyond 1½ inches and no borers were found above 4 feet from the ground, where the wood is very hard and dry. Below 4 feet, however, there is apparently enough dormant root tissue and moisture to provide the necessary succulence for its development. Owing to the rough, cracked nature of the coconut bark, it was not possible to locate the egg punctures. The exit holes, however, although inconspicuous, and the burrows which occasionally touched the surface, were plainly marked by a reddish-brown stain radiating downward, and in some instances by an exudation of gummy substance giving the "bleeding-disease" appearance. These facts are not alarming so far as the coconut palm is concerned, because the damage done to it is not severe, but they indicate that *R. obscura* may exist under a wide range of conditions and is a factor that must be reckoned with if sugarcane is to be grown on a commercial scale in Guam in the future.

The life history of this borer varies widely and apparently the pest in all stages may be found at any time during the year. In sugarcane the life cycle [4] from egg to adult occupies from 60 to 80 days or longer, the egg stage being fairly constant at 4 to 6 days, the larval stage at 50 to 60 days, and the pupal stage at 10 to 15 days. The adult, however, after shedding its pupal sheath, remains in the woven fiber cocoon at the end of the burrow until it becomes hardened and changed from the dirty white color of the pupa to the grayish brown and black spotted mature adult. This coloring and hardening process is apparently complete in a week, but the adult remains in the cocoon for a variable length of time before emerging. The period of aestivation varies from a few days to a week or more, and the stimuli which control the time are not clearly understood. The preoviposition period is not definitely known, but from observations and deductions it probably lasts from two weeks to a month, so that the length of time from egg to egg of *R. obscura* may be said to range from 89 to 125 days, which would allow for three or four generations per year. Sugarcane requires a year or more to mature, and the capacity of the pest to do great damage to the crop may be realized when it is considered that only a few of the larvae are necessary to riddle the inside of a stalk completely and quickly or that a single larva working at the base can so weaken a stalk as to cause it to be blown down by a high wind.

USE OF CEROMASIA SPHENOPHORI FOR SUGARCANE-BORER CONTROL

Fortunately for cane growers, the tachinid fly (*Ceromasia sphenophori*) holds the sugarcane borer in check wherever introduced successfully. This parasite was first introduced into Guam from Hawaii by the station in 1926. From the 115 puparia then received 28 flies emerged and were liberated in an infested cane field. Subsequent investigations failed to reveal any parasitization by the fly in the vicinity of the liberation and the attempt was considered a failure. Another attempt was then made to establish the fly, this time by breeding operations. To this end a second lot of puparia was requested of D. T. Fullaway, Territorial entomologist of Hawaii, through whose kindness 215 tachinid puparia and 56 parasitized larvae of *R. obscura* were received June 30 and July 1, 1927. The 56 larvae were received in individual glass vials containing bits of sugarcane for food. Unfortunately, all but 1 or 2 of the larvae were attacked by a white fungus, so that from this lot only 4 adult parasites were obtained. From the 215 puparia approximately 100 flies emerged. Breeding work was carried on in a small, badly infested field of soft sugarcane near the Togcha River.

A specially built cage for the puparia was made over a naturally infested stool of cane beside which artificially infested cane was set up in the ground. The cage was covered with a fine netting arranged so as to permit opening and closing the door, and was supported on posts each of which was set in a pan of water to exclude ants. Ants (*Solenopsis gemminata* var. *rufa*) soon made

[4] Life cycle as determined in a soft, juicy variety of cane supposed to have come originally from Java and the only variety on the island which can be classed as commercial. The larval stage requires a much longer time in the small, hard, so-called native and Japanese canes.

their appearance, however, and threatened to destroy both parasites and host material. Another cage was then built. This cage had a foot of soil on the floor and the supporting posts were set in pans of water. Fifty artificially infested stalks of sugarcane, including the material that had been used previously, were placed in the cage. Cockroaches ate the netting and many of the parasites escaped. The netting was then covered with wire screen. Artificially infested cane sections, each 5½ feet long, were placed in the cage in an upright position with their root ends inserted 6 or 8 inches in the soil. Holes, each one-quarter inch in diameter, were made in each section, one to each internode, and a nearly full-grown borer larva was placed in each hole. The holes were then plugged with frass from the larval runs. Each cane contained 8 to 12 grubs and the 50 canes approximately 500 grubs. To create as nearly natural conditions as possible for the tachinid fly, three or four papaya plants were placed among the cane stalks. This method of rearing is essentially the same as that used by the Sugar Planters' Experiment Station in establishing the parasite in Hawaii.

From the first generation only 18 adult parasites were obtained, and examination of the cane after emergence was completed showed that 80 of the puparia within the borer cocoons were empty. This large casualty is thought to have been caused by earwigs which lurked in the runs and captured the emerging flies before their wings had a chance to dry. Twenty-seven canes containing approximately 324 borer grubs were placed in the cage for the second generation and 180 adult parasites emerged. A check of the canes after emergence was completed revealed, as in the first generation, that only 50 per cent of the possible production emerged, the rest having escaped or been destroyed. Most of the second generation were used to start a third generation in the hope of getting a high production. The others were liberated in small infested cane areas in the vicinity of Togcha.

The first breeding operations were begun July 5 and emergence was completed August 23; the second generation was started August 18 and emergence was completed October 8; and the third generation was started September 23. In the meantime it was found that the escapes and the colony which was deliberately liberated in the vicinity of the cages had become well established. It was therefore decided to transfer breeding operations from Togcha to the station grounds to save time and energy used in making the frequent long trips to Togcha. Accordingly, all breeding material, including adult parasites and parasitized infested cane, were transferred to a cage at the station. Transfer of the cane caused it to dry out and become affected with a kind of dry rot, in consequence of which only 72 parasites were obtained from this generation. The area selected in the garden plat was found to be unsatisfactory because it afforded no protection from the hot winds and the sun, and the cage was moved to a more sheltered spot and the fourth generation started. Thirty-four canes were infested with 457 grubs on November 2.

When the borer grubs were being collected at Togcha for use in infesting canes for the fourth generation many cocoons of the borer were found containing puparia of the parasites and also numerous borers on which there were as many as 6 parasite larvae. Some of

these puparia were placed in vials for observation. The flies emerged early in the morning and most of them were found to have their wings extended for flight by 8 a. m. No flies issued after this time until the next morning. The flies from the fourth generation began to emerge December 5. Prior to this date there were occasional emergences due to the inadvertent use of parasitized borers in infesting the cane. The emergence of the main generation, however, was marked by the appearance of a large number of the flies. Because of the natural parasitization, it was impossible to check the emergence accurately, but well over 250 flies may be credited to this generation. These parasites were liberated in every infested cane area that could be located in the northern and central part of Guam, and lots of 20 to 40 were liberated in the southern part of Guam. From the data obtained, it was determined that the length of time required from egg to adult is 34 to 35 days, and that the entire life cycle, allowing one or two days for mating and oviposition, occupies 36 to 37 days.

A fifth and a sixth generation of these parasites were bred for the purpose of carrying them over until an opportunity was had to send them in sufficient numbers to the Sugar Cane Planters' Co. at Saipan, Marianas Islands, 120 miles north of Guam. This shipment was undertaken at the request of D. T. Fullaway, of Hawaii. Unsuccessful attempts had been made during the past few years to introduce this parasite into Saipan from Hawaii via Japan and Formosa. In collecting grubs for the purpose of these two generations an increasing number of borer grubs were found to be parasitized at Togcha. At this time over 50 per cent of the borers collected were parasitized, and from 30 of them, which were retained in the laboratory for checking, 57 parasites emerged ranging from only one parasite to as high as five per grub, with an average of three parasites.

A shipment consisting of 16 infested and parasitized cane stalks estimated to contain 150 to 200 parasites together with 105 parasite puparia packed in damp moss, 67 supposedly parasitized borer grubs, and 11 adult parasites, or an estimated 350 to 400 parasites, was sent to Saipan February 8, 1928. Written instructions accompanied the shipment regarding its care, disposition, and breeding operations. Subsequent information was received at Guam showing failure to establish the parasite in Saipan. In addition to the lot sent to Saipan over 200 parasites from the fifth and sixth generations were liberated in most of the cane areas in the vicinity of the station in lots of 20, and 50 were sent to the southern part of the island for liberation near Merizo.

EUROPEAN CORN-BORER PARASITES

On November 24 a consignment of the corn-borer parasite, *Exeristes roborator*, consisting of over 1,700 "spin-ups," [5] was received in good condition from the United States Corn Borer Station at Monroe, Mich. These parasites had been sent in cold storage and began to emerge 4 days after arrival and continued to emerge in numbers for 12 days. The largest number emerged the third, fourth, and fifth days, during which time 671 adults of a total of 1,113 were re-

[5] Full-grown larvae which have spun a thin, brown, parchmentlike cocoon.

covered during the 12-day period. Males predominated the first few days and females the last few days. This fact complicated proper mating and liberation of the females emerging after the fifth day, as the males were then very scarce and many of them died quickly in captivity. Of the 1,113, 477 were males 636 were females. All but 20 of the females and most of the males were liberated in the cornfields in the Barrigada and Dededo districts in numbers of 20 to 30 or more, according to the size of the field and the degree of infestation.

Most of the remaining spin-ups were apparently alive and made no attempt at transformation. These were set aside in a special cage and a few were found to emerge almost every day for a period of two or three months. A check of the 1,771 parasites two months after they were received showed that 492 had died, 127 were still alive as larvae, and 1,152, or a percentage of 66, had emerged. A month later 20 of the 127 live larvae had pupated and emerged. This slow emergence continued for a number of months and brought up the final emergence percentage to 70, which is considered very good considering the long distance and the length of time it took to get them to Guam.

The 20 females and 10 available males were retained for breeding in the insectary according to the methods worked out by the Bureau of Entomology at Arlington, Mass. Five males and 10 females were confined in small metal-lined cages having a glass front facing the light. Oviposition was induced by placing in the front part of the cage a short section of hollow cornstalk containing 6 to 8 full-grown borers with crushed mouth parts. The cornstalk was then covered with a thin strip of paper. In going toward the light the female parasites soon found the infested cornstalk and were stimulated to pierce the paper with their ovipositor, locate a borer, sting it into insensibility, and deposit an egg upon it. In this way as many as 200 parasite eggs were secured from the 20 females in one day. Each egg was placed in individual small glass vials. Corn borers were then submerged for 2½ minutes in water having a temperature of 126.5° F., after which one dead borer was introduced into each vial containing an egg. The eggs hatched in about 24 hours and the young larvae began to feed immediately.

Breeding work was started December 10 and by the end of the month 120 parasites had been reared to the spin-up stage. By February 8 the number had increased to 515, of which only 65 had pupated and emerged as adults. Slowness of transformation may have been an inherited characteristic inasmuch as the original stock used was from the slow transformations of the imported stock. The 65 adults that did emerge were used for further breeding purposes, so that there were no liberations of locally-bred parasites up to this time. Three hundred of the 500 spin-ups on hand at this time were placed in cold storage for use on the corn crop in May and also during the time the entomologist would be absent from the station on leave. The rest were left to emerge and to be used for liberations and breeding purposes. Those placed in cold storage were removed therefrom May 2. The package was in very poor condition, being soaked with water, but when the contents were dried out 125 larvae transformed and emerged as adults within the next few weeks.

Breeding operations which had been discontinued April 24 were resumed May 12. At the close of the year (June 30, 1928) a total of 850 parasites had been bred and liberated. Of these 537 were females and 313 were males. Eight hundred and ninety-three larvae were on hand in the spin-up stage, and some of these had been in this stage for three months without showing any signs of pupation. It was found that approximately one-half the larvae that reached the spin-up stage exhibited this tendency to hibernate, and that in general the retarded lot could be distinguished from the accelerated lot by the dark-brown color and dense texture of the cocoon in contrast to the thinner, light-brown color of the latter.

The life cycle of *E. roborator* under insectary conditions is very variable. Under optimum conditions of food and temperature and the like it may be summarized as follows: Egg stage, 1 day; larval stage, 7 days (feeding, 4 days, spinning, 1 day, and resting, 2 days); pupal stage, 7 days; and postpupal stage, 1 day. The emerging females are ready to begin egg laying by the third day, so that the entire life cycle may be carried through in 18 or 19 days. This may be called the short life cycle of the parasite. A few cases of even shorter cycles have been observed, but, on the other hand, there are many cases in which it is much longer. The egg stage is the most constant, occupying 20 to 30 hours, according to temperature, but very closely averaging 24 hours. The exact beginning of metamorphosis is hard to determine because it consists merely of a gradual lengthening of the larva, a constriction behind the head, and then a series of twists whereby the larval skin is cast off and the fully-formed pupa is exposed. The period lasts two or three days and is designated in the above-mentioned life cycle as "resting."

In the breeding work with this parasite the borer larvae used as food cause much trouble by decaying. Decay was not so noticeable after a series of comparatively cool days, but was considerable, with a consequent fatality among the feeding parasitic larvae, when the thermometer in the insectary registered about 90° F. Parasitic larvae can be saved when they leave the decaying mass and are removed to a clean vial and fed sound borers. More frequently, however, the parasitic larvae remain on the decaying borer and become affected by the decay and die. The decays attacking borer larvae in vials are red, brown, and black. Attacked by the red decay, the borer larvae retains its natural form but becomes soft and filled with a wet vermilion colored mass. The brown kind is a wet rot and causes the whole body to break down. The black kind is more or less of a dry rot and causes the borer larvae to shrink and harden. All the decays are characterized by an offensive odor.

A count of both imported parasites and those bred at the station shows that 1,850 were liberated in the cornfields of Guam. Of this number approximately 1,150 were females and 700 were males. The females in all instances were kept in captivity with the males and most likely were fertilized. Most of the liberations were confined to a few comparatively small districts in the hope of establishing bigger colonies than might be had from scattering them over wider areas. However, as yet there is no conclusive evidence to show that the parasite is at work in the fields.

HOUSE-FLY PARASITES

A small shipment of house-fly parasites (*Spalangia* sp.), a small black hymenopterous insect, was received from Doctor Fullaway, of Hawaii, November 24. All but one had emerged and died. This one was transferred to a small breeding cage containing fly pupae in moist sand from which three parasites were later taken and transferred to a breeding bottle prepared as was the cage. From the one Spalangia received in November and the three of the first generation in December a second generation of approximately 20 parasites was almost lost early in January because of a want of familiarity with the life cycle. Three females and two males, however, were still alive in the breeding bottle and were used to start a new generation. The previous generations were reared on fly pupae of any age obtainable in the field. It was thought at this time that the Spalangia preferred only newly transformed fly pupae. Accordingly, these were used in starting the third generation. Before this generation emerged, however, a large shipment of Spalangia was received consisting of three vials containing 38 adults, 4 of which were still alive, and 21 vials containing house-fly pupae in sand. Seven adult parasites were found in the vials containing fly pupae upon arrival. In the next 5 days 155 parasites emerged, which with the 4 arriving as adults, brought the total up to 159 parasites. Twenty-one of these were retained for breeding purposes and the rest were liberated at the station barn and pig shed.

That the parasites preferred newly transformed fly pupae to older fly pupae was proved by the results obtained from the third generation of the original importation of one live Spalangia. From the 150 fly pupae used as host material nearly 50 parasites were recovered, with only the 3 females and 2 males for breeding. Breeding operations with this parasite were continued on a small scale with success during the entomologist's leave of absence. It is almost impossible to obtain an accurate check of production because of the habits of the adults, which almost constantly enter and leave the sand and because of the difficulty of "drawing them off" from the jar for counting. Checking over the fly-pupae material left after an emergence was completed and counting the pupae showing the characteristic emergence hole of the parasite were found to be the best methods of determining production. This was done often enough to learn that as high as 80 per cent of the fly pupae in the breeding jars were parasitized. Unsatisfactory results in a few instances were had when fungus attacked most of the fly pupae and killed both parasites and flies.

It was soon found that the practice of placing full-grown fly larvae in the sand one day and introducing the parasites the next day gave better success than when the pupae were collected in the field for use. Most of the fly larvae had transformed by the second day and all had by the third day and thus served as fresh material for the parasites. Large candy jars were laid sidewise in about an inch of sand on which were placed 500 full-grown fly larvae and 50 Spalangia. The mouth of the jar was kept closed by means of a piece of unbleached muslin held in place by a rubber band. An attempt was made to "draw off" these parasites after they had been in the jar for four days for use as breeding stock in other prepared jars.

Transferring them proved to be so difficult that they were left to complete their work and die. Proper moisture conditions in the jars were maintained by blowing in water through the muslin cover by means of an atomizer.

The time elapsing from the introduction of the parasites into the breeding jars to the appearance of the first adults of the succeeding generation ranged from 17 to 19 days. If 2 days are allowed for mating and oviposition to begin, the time from egg to adult stage may be said to cover about 15 to 17 days. An examination of parasite fly pupae 10 days after the introduction of the adult parasites showed an almost equal number of full grown parasite larvae and newly transformed parasite pupae. It is concluded, therefore, that, allowing 1 day for the egg stage, both the larval and pupal stages occupy approximately 7 to 8 days.

This parasite is now fairly well established around the sheds, barn, and manure dump of the station. Liberations to date include 788 adults from the breeding operations and a number of small lots of 25 to 50 parasites collected in the field for persons interested in establishing them around their premises.

MISCELLANEOUS NOTES

The coconut scale (*Aspidiotus destructor*) continued under complete control and in fact was so hard to find that, in filling a request for specimens, it took an hour of diligent search to locate a good colony in the very coconut grove which two or three years before was threatened with extinction by the pest. In all instances where the scale is found it is invariably attended and controlled by the small black ladybird beetle (*Cryptogonus nigripennis*).

The Chrysomelid leaf-eating beetles referred to in last year's report [6] as damaging the new growth of various kinds of trees have been identified by the Bureau of Entomology of the United States Department of Agriculture as *Phytorus pinguis*. There seems to be no available data on this particular species. A related species, *P. dilatatus*, is reported from the Malay States as being injurious to tea, cacao, and other cultivated plants. It is stated that this insect lays its eggs in batches upon the midrib and axils of the leaves on which the adults feed, but no information is given regarding the location or habits of the larvae. It is thought that *P. pinguis* came to Guam from the Philippine Islands. The writer saw specimens of this species under the name of *P. lineolatus* at the Bureau of Agriculture in Manila. The bureau was then engaged in working out the life history of the beetle, but could offer no information on the eggs and larvae. Such information is of importance in combating the insect under Guam conditions because there are no commercial host plantings or even host plantings of sufficient size to warrant the outlay necessary for spraying operations by native ranchers. Mangoes and other plants affected by the beetle are found growing only in small clusters or about the dooryards of the native ranch houses. On the other hand, if the larval habits and situation were

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[6] VANDENBERG, S. R. REPORT OF THE ENTOMOLOGIST. Guam Agr. Expt. Sta. Rpt. 1927: 16. 1929.

known such cultural operations as are easily understood by the natives would likely be of avail in reducing the damage from the pest.

From an entomological standpoint the year has been favorable, probably because of optimum growing conditions and a more equable distribution of rainfall than usual. There were no prolonged droughts during the dry season, and, as compared with previous years, few requests for aid or for information in combating pests were received at the station.

METEOROLOGICAL OBSERVATIONS, 1927–28

Observations made at the station on temperature, precipitation, and wind are summarized in Table 4.

TABLE 4.—*Condensed meteorological data for the year ended June 30, 1928*

Month	Temperature					Total precipitation	Prevailing direction of wind
	Maximum	Minimum	Mean maximum	Mean minimum	Monthly mean		
1927	° *F.*	° *F.*	° *F.*	° *F.*	° *F.*	*Inches*	
July	89.0	74.0	86.44	75.81	81.12	12.14	Southeast.
August	89.0	73.5	86.36	76.10	81.23	17.54	Do.
September	89.0	73.0	86.66	75.44	81.05	6.14	Northwest
October	89.5	70.0	86.98	75.82	81.40	7.19	Northeast.
November	90.0	74.5	87.07	76.85	81.96	5.98	Do.
December	88.5	72.5	86.46	76.37	81.41	6.30	Do.
1928							
January	89.0	71.5	85.74	75.63	80.68	3.35	Do.
February	88.5	73.5	85.84	74.81	80.32	3.23	East.
March	87.5	72.0	85.96	74.83	80.39	4.31	Do.
April	89.5	74.0	87.73	76.30	82.01	.46	Northeast.
May	89.0	75.0	87.23	76.68	81.95	4.76	Do.
June	89.0	74.0	86.83	76.64	81.73	6.63	Southeast.
Total						78.03	